Space Weather Technical Forecast

Issued on Thursday 10 October 2024 at 01:30 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Chance of X-class flares. Ongoing S2/S3 Moderate/Strong Solar Radiation Storm. G1-G2 Minor/Moderate storms expected, chance of G3/Strong storms and slight chance of G4/Severe storms days 1 and 2.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Activity has been at High levels with an X1.8 flare peaking at 09/0156 UTC from AR3848, plus an X1.4 peaking at 09/1547 UTC and a M7.7 peaking at 09/2312 UTC both from AR3842. There are currently eight sunspot regions visible, of which five are numbered. Of these AR3842, AR3848 and AR3849 all have Eki/beta-gamma-delta classifications, AR3852 is classified as Eki/beta-delta and the remaining regions are small and simple. The largest region remains AR3848, and the region appears stable since the filament eruption which triggered the X-1.8 flare on the 9th. There are also several filaments on the disc.

A large material-rich full halo CME was observed leaving the Sun in association with the X1.8 flare and filament eruption early on 09 Oct. This CME has been analysed as arriving at Earth late on the 10 the or early 11th Oct.

Another CME was seen leaving the Sun in association with the X1.4 flare from AR3842, but as this region is on the west limb this CME is not expected to be Earth directed. Analysis will be undertaken to confirm this.

Solar Wind / Geomagnetic Activity: The period was indicative of waning CME and coronal hole high speed stream influence. Solar wind speed was mainly slightly elevated, generally between 400-450km/s, but temporarily decreased to background levels around 300 km/s for a time later in the day. The density was generally below average, but did occasionally reach average values. Interplanetary Magnetic Field, Bt, was initially Moderate at 8-9nT, but gradually declined to Weak levels, ending the period at 5nT. The north-south component, Bz, favoured a negative (southward) orientation with fluctuations between +4 to -8 nT, with only brief spells of positive (northward), on a weakening trend. Phi angle was predominantly positive (away from the Sun). Geomagnetic activity was Active to G1/Minor Storm (Kp 4-5) decreasing Quiet (Kp 2).

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux, observed by GOES18, was initially at background levels before responding to the X1.8 flare on 9th Oct,. The high energy protons rose to reach S3/Strong storm levels, peaking at 1.14e3 pfu at 09/2215 UTC. High energy electron flux (greater than 2MeV) observed by GOES16 was initially at background

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levels, but increased to reach Moderate levels, peaking at 363 pfu at 09/1800 UTC. The associated 24-hour fluence was below the Active threshold with 1.37e6 observed at 09/0900UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity is expected, with a chance of isolated X-class flares until day 2 (11 Oct). From then activity is then expected to decrease Low to Moderate, but with a slight chance of X-class flares.

Solar Wind / Geomagnetic Activity: There are two CMEs which may glance Earth early (10 Oct). A large full halo CME is then expected to arrive at Earth late today or early tomorrow (10/11 Oct).

Solar winds are currently slightly elevated, with a slight chance of increasing to 500-550 km/s should any of the glancing CMEs have peripheral impacts at Earth from early today (10 Oct). Later today or early tomorrow (11 Oct), the full halo CME is expected to arrive, perhaps increasing wind speeds to around 700km/s. Solar wind speeds should then gradually decrease to slightly elevated levels (400-500 km/s) through day 3 (12th) perhaps down to background levels for day 4 (13th). However, late day 4 a weak high speed stream (HSS) may arrive from CH79.

Geomagnetic activity is expected to be Quiet to Unsettled (Kp 2-3) initially with a chance of isolated Active to G1/Minor storms intervals (Kp 4-5) due to glancing CMEs. Activity is then expected to increase later today or early tomorrow (10/11 Oct) due to the arrival of the full halo CME, bringing expected G1-G2/Minor-Moderate storms (Kp 5-6), a chance of G3/Strong storms (Kp 7) and a slight chance of G4/Severe storms (Kp 8), with the peak of the activity weighted to tomorrow (11 Oct). Through day 3 (12 Oct) geomagnetic activity should begin to decline, becoming predominantly Quiet to Active (Kp 2-4), but with a chance of G1/Minor Storms (Kp 5), due to any residual CME effects. Day 4 Quiet to Unsettled activity (Kp 2-3) is likely, with perhaps a chance of Active (Kp 4) intervals late in the day.

Energetic Particles / Solar Radiation: High energy proton flux at GOES18 is currently at S2/Moderate storm levels, but not far below the S3/Strong storm level, due to a response from a combined X1.8 and filament eruption on 09 Oct. The proton flux is likely to rise above the S3/Strong level at times today and tomorrow, especially after further CME influence. From day 3 (12th) levels are expected to gradually fall.

High energy electron flux is expected to remain at Moderate levels but may diurnally reach High levels today and again during day 4 (13th), but is likely to be suppressed in-between due to CME interactions. The associated 24 hour election fluence is expected to remain below the Active threshold (1e8 total pfu), despite a rising trend.

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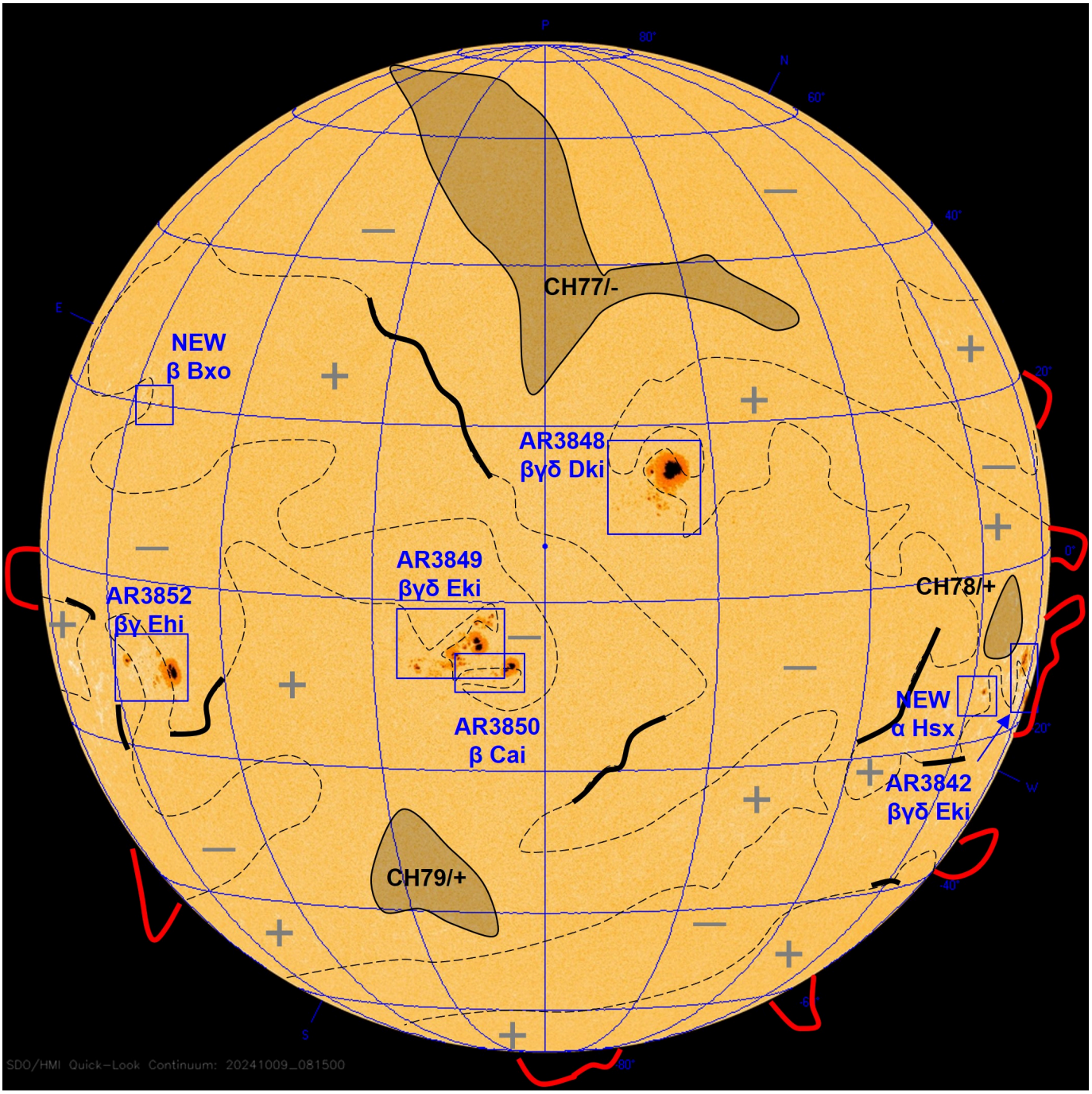
Figure 1: Solar synoptic map valid 09/0800 UTC



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

The large and bright CMEs evident from the X2.1 and X1.0 flares are expected to miss Earth but may have an outside chance of glancing impacts, perhaps early today (10 Oct). A large filament eruption was also seen to leave the Sun early on 08 Oct, it appears to be mostly south directed, but a weak glancing blow from the associated CME is possible also the 10th or 11th. A large material-rich full halo CME was observed leaving the Sun in association with the X1.8 flare and filament eruption early on 09 Oct. This CME has been analysed as arriving at Earth late 10 or early 11 Oct.

Solar winds are currently slightly elevated, with a slight chance of increasing to 500-550 km/s should any of the glancing CMEs have peripheral impacts at Earth. The full halo CME may increase wind speeds to around 700km/s. Solar wind speeds should then gradually decrease to slightly elevated levels (400-500 km/s) through day 3 (12th) perhaps down to background levels for day 4 (13th). However, late day 4 a high speed stream (HSS) may arrive from CH79. This coronal hole feature is smaller compared to last rotation, and is quite a way south, and therefore any connection with Earth is likely to be weak, with a HSS reaching around 450 km/s.

Geomagnetic activity is expected to be Quiet to Unsettled (Kp 2-3) initially with a chance of isolated Active to G1/Minor storms intervals (Kp 4-5) due to glancing CMEs. Activity is then expected to increase later today or early tomorrow (10/11 Oct) due to the arrival of the full halo CME, bringing expected G1-G2/Minor-Moderate storms (Kp 5-6), a chance of G3/Strong storms (Kp 7) and a slight chance of G4/Severe storms (Kp 8), with the peak of the activity weighted to tomorrow (11 Oct). Through day 3 (12 Oct) geomagnetic activity should begin to decline, becoming predominantly Quiet to Active (Kp 2-4), but with a chance of G1/Minor Storms (Kp 5), due to any residual CME effects. Day 4 Quiet to Unsettled activity (Kp 2-3) is likely, with perhaps a chance of Active (Kp 4) intervals late in the day.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	**G1 to G2**	Yes	80	80	60	20
Strong	**G3**	No	40	50	20	1
Severe	**G4**	No	10	20	5	1
Extreme	**G5**	No	1	5	1	1

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Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R⊙ (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed (km/s)	Estimated Arrival Time (UTC)	Comments
09/05:00	Full	AR3848	7W12N	1270	10/2200	High confidence for CME to reach Earth but lower confidence for arrival time.

Figure 2: MOSWOC Enlil

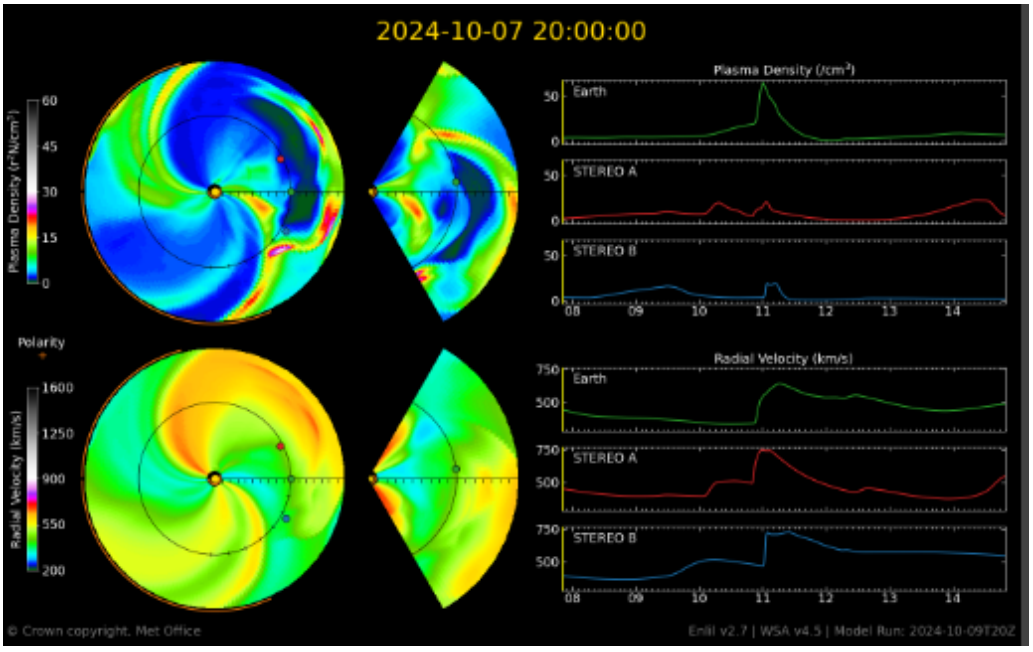

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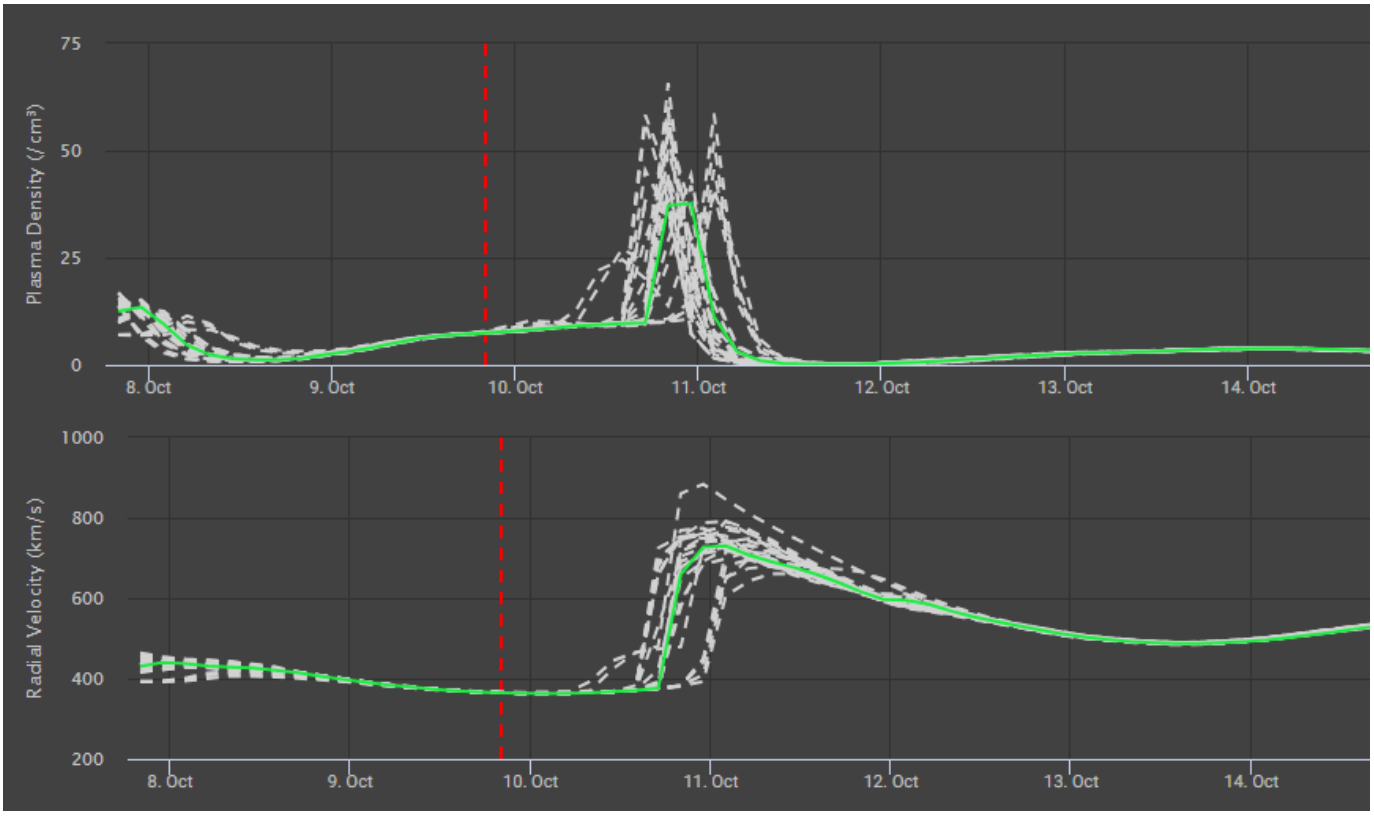
Figure 3: MOSWOC Enlil ensembles



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Radio Blackouts - X-Ray Flares

Activity has been at High levels with an X1.8 flare peaking at 09/0156 UTC from AR3848, and an X1.4 from AR3842 peaking at 09/1547UTC . A M7.7 flare also occurred, peaking at 09/2312 UTC from AR3842.

There are currently five numbered sunspot regions visible. AR3842 is now in it's transit around the limb and therefore it's previous classification is preserved, with a delta still thought to be present. AR3848 in the north-centre has a large mature positive leader, with numerous small trailing spots and weak penumbra surrounding them, there remains a very weak delta to the southeast penumbra of the main spot. Previously there was some small spot development to the rear, but recently some of these spots have faded. AR3849 and AR3850 remain very close to each other in the southeast near centre disk and are hard to distinguish one from the other. The more westward spot, AR3849, continues a gradual shrinking and simplifying trend. For AR3850 penumbra has shrunk around some small leading northern spots, allowing the previous delta spot there to decay. However, a very small delta spot persists in one of the southern trailing spots. AR3852 in the southeast appears to be developing small trailing spots again. There are three new regions, all of which remain small and simple but with slight growth trends.

There is an ongoing chance of isolated X-class flares, mainly from AR3848, AR3842 or AR3849. As AR3842 will soon be rotating off behind the west limb a decreasing risk of flares is expected over the next 3 days. However, new or returning regions are likely to rotate onto the visible disc during the forecast period, and solar activity may increase again.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	80	60	60	60
Very Active	R3-R5 (X Class)	Yes	30	20	10	10

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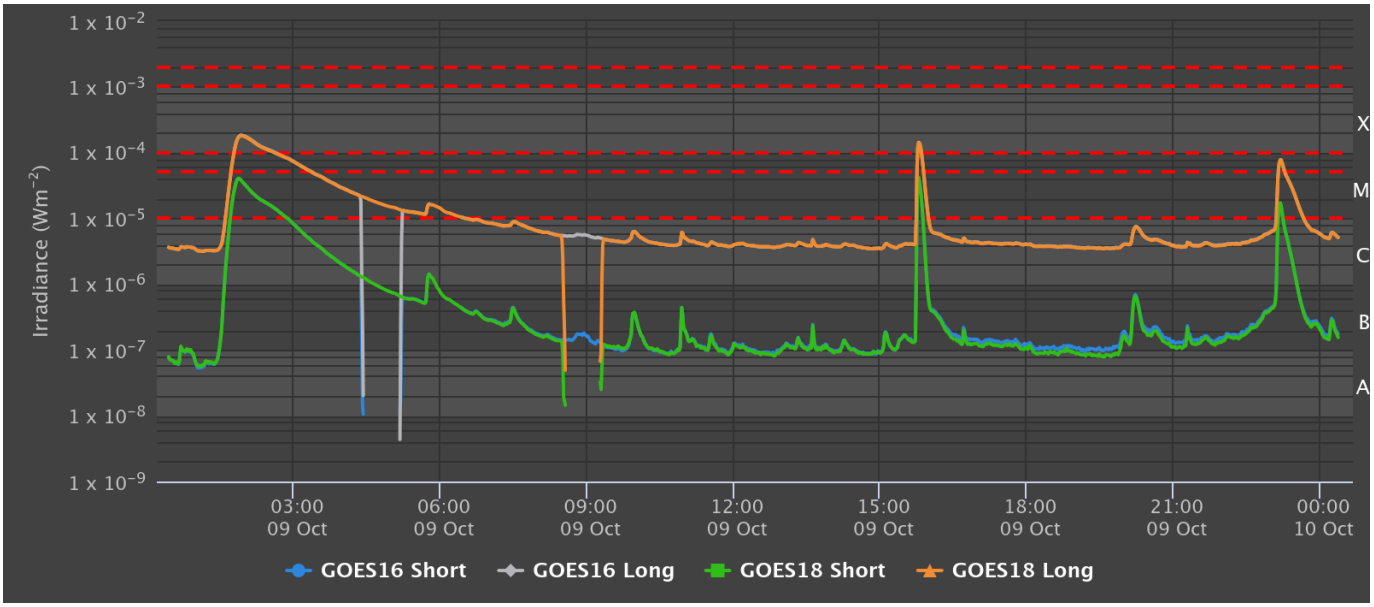
Figure 4: GOES X-ray flux for past 24 hours



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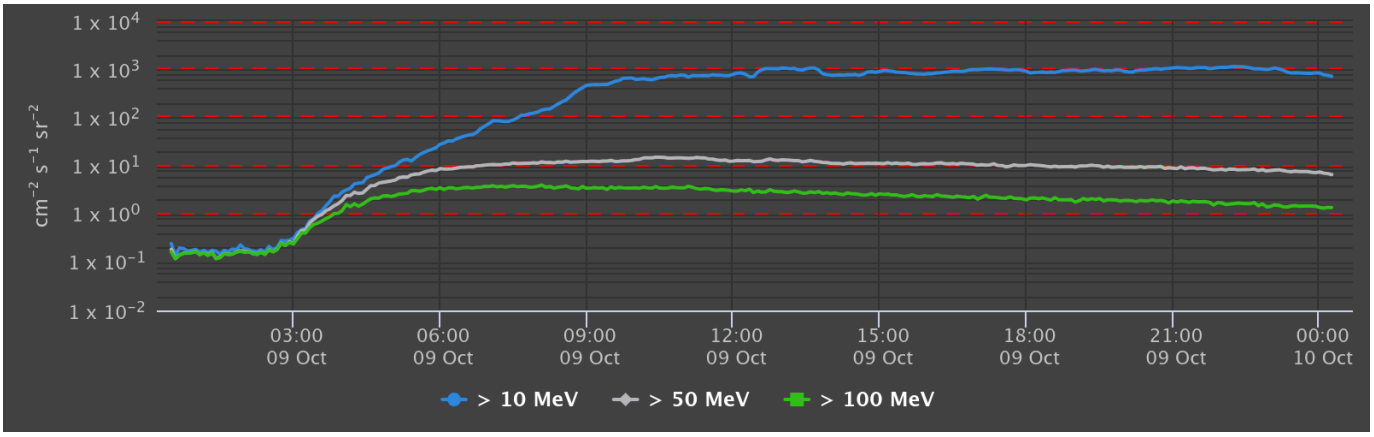
Solar Radiation Storms (High Energy Protons)

High energy proton flux at GOES18 is currently at S2/Moderate storm levels, but not far below the S3/Strong storm level, due to a response from a combined X1.8 and filament eruption on 09 Oct. The proton flux is likely to rise above the S3/Strong level at times today and tomorrow, especially after further CME influence. From day 3 (12th) levels are expected to gradually fall, although there remains a chance of further enhancement given both AR3842 and AR3848 remain in favourable locations should any further notable flares occur.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	100	95	60	30
Very Active	**≥ S3 ***	Yes	70	60	20	5
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 5: GOES18 Proton Flux



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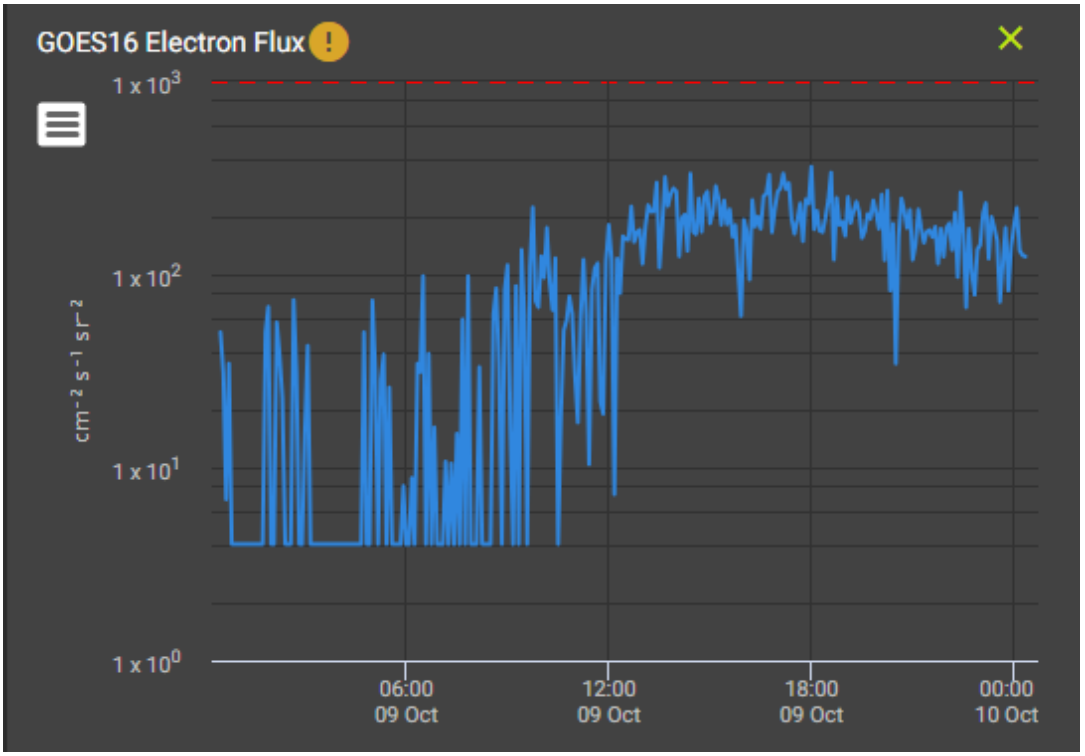
High Energy Electrons (≥ 2MeV)

High energy electron flux is expected to remain at Moderate levels but may diurnally reach High levels today, and again during day 4 (13th), but is likely to be suppressed in-between due to CME interactions. The associated 24 hour election fluence is expected to remain below the Active threshold (1e8 total pfu), despite a rising trend.

The REFM model supports a rising trend, whilst remaining below the Active threshold during the next three days. This is accepted as reasonable guidance.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	10	10	20	40
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

Figure 6: GOES 16 Electron Flux for the past 24 hours



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